Adenocarcinoma of the Esophagus: Role of Obesity and Diet

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Background: **In the United States, the incidence of adenocarcinoma of the esophagus, including the esophagogastric junction, has been increasing rapidly over the past two decades. Except for an association with Barrett's esophagus, little is known about the etiology of these cancers.** ***Purpose:*** **Our purpose was to investigate dietary and nutritional risk factors for adenocarcinoma of the esophagus.** ***Methods:*** **A population-based, case–control interview study of 174 white men with adenocarcinoma of the esophagus and 750 control subjects living in three areas of the United States was conducted during 1986 through 1989.** ***Results:*** **Risk was significantly elevated for subjects in the heaviest quartile compared with the lightest quartile of body mass index (odds ratio [OR] = 3.1; 95% confidence interval [CI] = 1.8-5.3). No significant associations were seen with total calories from food, number of meals eaten per day, level of fat intake, or consumption of coffee and tea. Risks were highest for those consuming the least amount of vegetables, with some evidence of a dose response for the subcategories of cruciferous vegetables (*P* for trend <.001) and vegetables consumed raw (*P* for trend = .10). A significantly elevated risk was also seen for those consuming the least amount of raw fruit (*P* for trend = .05). No clear associations were reported for intake of particular micronutrients overall or in supplements, but a significant protective effect was associated with increasing intake of dietary fiber (*P* for trend = .004).** ***Conclusions:*** **The findings of an increased risk with obesity and decreased risks with intake of raw fruits and vegetables and dietary fiber provide useful directions to pursue in further investigations of this malignancy.** ***Implications:*** **The finding with respect to obesity is particularly noteworthy, since it may explain at least a portion of the recent epidemic increases reported in the incidence of this tumor. [J Natl Cancer Inst 87:104-109, 1995]**

During the past two decades, the incidence of adenocarcinomas of the esophagus and gastric cardia, including the esophagogastric junction, has been increasing rapidly (*1*). The average annual age-adjusted incidence of adenocarcinoma of the esophagus among white men, the race–sex group with the highest incidence rates, tripled from 0.8 per 100 000 in 1976 through 1978 to 2.5 per 100 000 in 1988-1990 (*2*). The corresponding incidence rates for adenocarcinoma of the gastric cardia increased from 2.3 per 100 000 to 3.4 per 100 000. Except for an association with Barrett's esophagus, a recognized precursor lesion for adenocarcinoma of the esophagus (*3,4*), little is known about the etiology of these cancers. As part of a case–control study designed to evaluate reasons for the excess incidence of squamous cell carcinoma of the esophagus among

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black men compared with white men, data were also collected on subjects with adenocarcinomas of the esophagus and esophagogastric junction. The major nondietary risk factors for adenocarcinomas of the esophagus and esophagogastric junction previously identified in this study (*5*) included the use of cigarettes (odds ratio [OR] = 2.1; 95% CI = 1.2-3.8), liquor (OR = 1.6; 95% CI = 1.1-2.4), recent annual income less than $10 000 (OR = 3.4; 95% CI = 1.5-7.4), and history of ulcer (OR = 1.7; 95% CI = 1.1-2.6). This article investigates the possible role of diet and nutrition in the etiology of these cancers.

Subjects and Methods

Concurrent population-based, case–control interview studies of four cancers that occur in excess among blacks (cancers of the esophagus, prostate, and pancreas and multiple myeloma) were conducted during 1986 through 1989 in three areas of the United States. For efficiency, one large control group was selected for all four cancer types. Only male case patients with esophageal cancer were included, because the number of female case patients available would have been too few to analyze (the number of affected females is about one third the number of affected males).

All histologically confirmed cases of esophageal cancer (International Classification of Diseases for Oncology [ICD-O], 1976, site code 150) or cancer of the esophagogastric junction (ICD-O site code 151.0), newly diagnosed between August 1, 1986, and April 30, 1989, among white and black men aged 30-79 years, were initially selected for the study. Case patients were residents of geographic areas covered by three population-based cancer registries: the Georgia Center for Cancer Statistics (DeKalb and Fulton counties), the Metropolitan Detroit Cancer Surveillance System (Macomb, Oakland, and Wayne counties), and the New Jersey State Cancer Registry (Atlantic, Burlington, Camden, Essex, Hudson, Mercer, Middlesex, Monmouth, Passaic, and Union counties). Because survival rates for this disease are unfavorable, a rapid reporting system was established to facilitate ascertainment and interview of patients with esophageal cancer. Case patients were identified from pathology and outpatient records at hospitals in the catchment areas. The median number of days between date of diagnosis and interview was 49. Pathology records were used to divide the case patients with esophageal cancer (ICD-O site code 150) into three histologic groups: squamous cell carcinoma (ICD-O site codes 8050-8082), adenocarcinoma (ICD-O site codes 8140-8573), and all other histologic types, including carcinomas not otherwise specified.

For each of the three geographic study areas, registry data for all four main cancer types were used to estimate the race- and age-specific (5-year age groups) numbers of case patients anticipated in order to construct a sampling frame for control subjects. Control subject selection used two sources: a random-digit-dialing technique (*6*) for control subjects aged 30-64 years and random sampling from computerized listings of Medicare recipients provided by the Health Care Financing Administration (HCFA), Baltimore, Md., for control subjects aged 65-79 years.

In-person interviews lasting approximately 60 minutes were conducted by trained interviewers, usually in the homes of the subjects. Detailed information was obtained on medical and dental history, use of alcohol and tobacco, usual occupation, sociodemographic factors, and usual adult diet. Since the study was originally designed to collect information primarily on squamous cell tumors, information was not collected on factors related to adenocarcinoma, including Barrett's esophagus or medical conditions related to Barrett's esophagus, such as esophageal reflux or hiatal hernia.

The dietary assessment methodology was described in detail elsewhere (*7*). Briefly, the dietary section of the interview contained a 60-item food-frequency questionnaire plus six additional questions about the consumption of fried foods. Subjects were asked to recall their usual adult frequency (i.e., times per day, week, month, or year), excluding the past 5 years, of consumption of specific food items (e.g., ice cream, broccoli, or bananas) or groups of similar food items (e.g., beef, such as hamburger, steak, or pot roast; kale and collard, mustard, or turnip greens). The individual foods that contribute to each food group are listed in Appendix table 1. Subjects were also asked about their use of vitamin supplements, including multivitamins, vitamin B (complex), and vitamins A and C, and how often they drank coffee and tea.

Of the 317 white male case patients interviewed, 174 had adenocarcinomas (113 with esophagogastric junction cancer; 61 with adenocarcinoma of the esophagus), 124 had squamous cell carcinomas, and 19 had other or unspecified esophageal cancers. Among the 270 black male patients interviewed, 10 had adenocarcinomas (eight with esophagogastric junction cancer; two with adenocarcinoma of the esophagus), 249 had squamous cell carcinomas, and 11 had other or unspecified esophageal cancers. In this article, we limit analyses to adenocarcinomas of the esophagus and esophagogastric junction. Because of the small number of these tumors among black men, it was decided, for statistical considerations, to restrict this analysis to the 174 white male case patients with adenocarcinomas of the esophagus and esophagogastric junction and to the 750 white male control subjects.

At the interview phase, the response rates were 74% for the case patients with adenocarcinoma, 72% for the control subjects provided by the HCFA, and 76% for the control subjects provided by random-digit dialing. A census of the household (used to sample control subjects who were <65 years of age) was provided by 86% of the households contacted using random-digit dialing. Among all white control subjects, refusal to be interviewed was the most common reason for nonresponse (18%), followed by too ill or deceased (4%); reasons for case patient nonresponse included deceased (12%), too ill (8%), or refusal to be interviewed (5%).

To evaluate dietary patterns, we categorized individual foods into food groups. Nutrient intakes were estimated on the basis of the frequency of consumption of each food item and the nutrient content of an average serving for males obtained from the National Health and Nutrition Examination Survey (NHANES II) nutrient database (*8*). Four consumption categories ranging from low to high were created for each food group and nutrient index by dividing the frequency distribution for the control subjects into approximate quartiles.

The major nondietary risk factors previously identified in this study (*5*) included cigarettes (OR = 1.1, 2.4, and 2.6 for <20, 20-39, and ≥40, respectively, smoked per day compared with none), liquor (OR = 1.3, 1.8, 2.1, and 2.8 for <8, 8-14, 15-28, and ≥29, respectively, drinks per week compared with none), recent annual income (OR = 1.6, 1.7, and 3.4 for $25 000-49 999, $10 000-24 999, and <$10 000, respectively, compared with ≥$50 000), and history of ulcer (OR = 1.7 for yes compared with no). Data were analyzed with the use of unconditional logistic regression (*9*). Adjusted ORs and 95% confidence intervals (CIs) were obtained with the use of the EPICURE programs for personal computers (*10*). All models included the selection factors of age and geographic area and potential confounders, including cigarettes, liquor, and recent annual income. Body mass index (BMI) (kg/m^2) and total calories from food (not including those from alcohol) were also included in all food group and nutrient analyses. Adjustment for history of ulcer and other social class variables, such as education and marital status, did not substantially alter any of the risk estimates and thus these variables were not included in the final models. To test for linear trend, we entered categorical variables as continuous variables in the logistic models using as scores the median values of each category in the control group.

Analysis of food groups, nutrients, and dietary factors (BMI, total calories from food, and number of meals per day) was based on 162 case patients and 685 control subjects. Excluded from the dietary analysis were the 12 (6.9%) case patients and the 65 (8.7%) control subjects who answered fewer than 95% of the individual food items in the questionnaire or whose dietary records were considered to be unreliable (e.g., individuals with extremely high or low values for the total amount of food consumed).

Results

The median age was 63 years for case patients and 61 years for control subjects. Most of the interviewed (68%) and noninterviewed (77%) case patients with adenocarcinomas of the esophagus and esophagogastric junction were residents of Detroit. There was a surprising paucity of case patients from New Jersey (19% of the interviewed case patients and 10% of the noninterviewed case patients). Although the reason is unclear, the low percentage from New Jersey may be related to the underascertainment of case patients or to the demographics of the study counties that were selected to provide a large number of black case patients to investigate their high rate of esophageal

carcinoma. The control subjects were more evenly distributed over the three geographic areas (e.g., Atlanta, 22%; Detroit, 37%; and New Jersey 41%), reflecting the combined distributions of the four major cancer types involved in the overall study.

The adjusted OR for adult BMI was significantly elevated for subjects in the heaviest quartile compared with the lightest quartile of BMI (OR = 3.1; 95% CI = 1.8-5.3; Table 1). The dose pattern became even more striking when the heaviest quartile was divided in two. Adjusted ORs were 2.5 (95% CI = 1.3-4.7) for a BMI of 26.6-28.9 kg/m^2 and 3.9 (95% CI = 2.1-7.4) for a BMI greater than 28.9 kg/m^2. The risk for the heaviest quartile remained elevated (OR = 2.6; 95% CI = 1.4-4.9) when subjects with a history of ulcer were removed from the analysis. Although numbers were smaller and dose patterns were less clear, an elevated OR for the fourth quartile of BMI was observed for each registry. No significant associations were seen with the intake of total calories from food (although risk was nonsignificantly increased for the highest intake level) or with the number of meals eaten per day.

Adjusted ORs for the major food groups and subcategories of food groups are shown in Table 2. No consistent patterns of either increased or decreased risk were seen for consumption of dairy products; bread, grains, and cereal; or meat, poultry, and fish. However, decreased risks were seen for consumption of fruits and vegetables. For consumers of raw fruits, raw vegetables, and cruciferous vegetables, the risks for the highest intake levels were significantly reduced when compared with those for the lowest categories. The reductions were observed across all registries and remained when analysis was restricted to subjects without a history of ulcer. For cruciferous vegetables, a significant gradient of decreased risk with increased consumption was observed.

Table 3 shows adjusted ORs for the consumption of specific nutrients. Although risks were not increased for total fat intake,

Table 1. ORs for adenocarcinomas of the esophagus and esophagogastric junction in white men according to dietary factors

Factor	No. of case patients	No. of control subjects	OR*	95% CI
BMI, kg/m^2†				
<23.1	24	172	1.0	—
23.1-25.0	31	170	1.1	0.6-2.1
25.1-26.6	27	169	1.2	0.6-2.3
>26.6	79	171	3.1¶	1.8-5.3
Unknown	1	3		
Total calories from food‡				
<1397	28	171	1.0	—
1397-1769	39	171	1.3	0.7-2.3
1770-2136	34	172	1.0	0.6-1.8
≥2137	61	171	1.5	0.8-2.6
No. of meals/day§				
≥3	109	451	1.0	—
<3	53	234	0.9	0.6-1.4

*All estimates were adjusted for age, area, smoking, liquor use, and income.
†Estimates were adjusted for calories from food.
‡Excludes calories from alcohol; estimates were adjusted for BMI.
§Estimates were adjusted for calories from food and BMI.
¶P <.001.

Table 2. ORs for adenocarcinomas of the esophagus and esophagogastric junction in white men according to consumption level of food groups*

Food group	Quartiles of consumption 1 (low)	2	3	4 (high)	P
Dairy products	1.0	1.3	1.2	1.1	.98
Bread, grains, and cereal	1.0	1.0	1.2	1.1	.59
Breaded and fried foods	1.0	1.6	1.4	1.4	.77
Meat, poultry, and fish	1.0	1.1	0.6	0.7	.12
Poultry and fish	1.0	0.6†	0.8	0.9	.70
Red meat	1.0	1.3	0.9	0.8	.21
Processed meats	1.0	1.0	0.8	0.7	.28
Fruits	1.0	1.0	1.0	0.7	.24
Citrus and juices	1.0	1.7	1.3	1.1	.95
Citrus	1.0	0.6	0.6	0.7	.77
Noncitrus	1.0	0.7	0.4†	0.6	.07
Raw	1.0	0.4†	0.5†	0.4†	.05
Vegetables	1.0	0.5†	0.6	0.6	.20
Cruciferous/vitamin C rich	1.0	0.5†	0.5†	0.3†	<.001
Dark green	1.0	0.8	0.8	0.6	.11
Dark yellow	1.0	0.6	0.7	0.6†	.11
Legumes	1.0	0.8	0.8	0.6	.10
Raw	1.0	0.5†	0.5†	0.4†	.10

*All estimates were adjusted for age, area, smoking, liquor use, income, calories from food, and BMI.
†95% CI does not include 1.0.

Table 3. ORs for adenocarcinomas of the esophagus and esophagogastric junction in white men according to consumption of specific nutrients*

Nutrient	Quartiles of consumption 1 (low)	2	3	4 (high)	P
Protein	1.0	0.5	0.3†	0.4	.11
Fat	1.0	1.0	1.0	1.1	.90
Saturated fat	1.0	1.3	1.1	1.7	.36
Carbohydrates	1.0	1.3	1.3	1.9	.20
Cholesterol	1.0	0.7	1.1	1.1	.42
Fiber	1.0	0.6	0.5†	0.4†	.004
From fruit	1.0	0.7	0.7	0.5†	.06
From vegetables	1.0	0.6†	0.6	0.6	.21
Niacin	1.0	0.7	0.3†	0.7	.54
Riboflavin	1.0	1.1	0.8	0.9	.85
Thiamine	1.0	0.7	0.5	0.5	.24
Vitamin A	1.0	1.0	0.9	0.8	.33
From fruit	1.0	1.5	1.0	0.9	.38
From vegetables	1.0	0.6	0.7	0.7	.32
From animal sources	1.0	0.8	0.8	0.7	.43
Vitamin C	1.0	1.4	1.0	0.9	.42
From fruit/juices	1.0	1.9	1.3	1.2	.90
From vegetables	1.0	0.5†	0.6	0.5†	.07
Folate	1.0	0.8	0.6	0.6	.16
Iron	1.0	0.5	0.3†	0.5	.51
Calcium	1.0	0.9	1.2	1.0	.89

*All estimates were adjusted for age, area, smoking, liquor use, income, calories from food, and BMI.
†95% CI does not include 1.0.

risk was nonsignificantly elevated (OR = 1.7; 95% CI = 0.6-4.9) for the highest intake level of saturated fat. A significant dose–response trend was seen for fiber intake; risks were significantly reduced for the two highest quartiles of consumption compared with the lowest quartile. Similar findings of reduced risk with heavier consumption were seen when ORs were calculated separately for each registry and when subjects with a history of ulcer were removed. Separate ORs for fiber derived from fruit and from vegetables also showed patterns of reduced risk with increased consumption, although trend tests were not significant and risk gradients were less striking than those for all sources of fiber combined. No significant trends were seen with the consumption of vitamin A from fruit, vegetables, or animal sources. Although intake of dietary vitamin C did not show a clear pattern overall, reduced risks were seen for the three highest categories of vitamin C intake from vegetables.

ORs associated with use of vitamin supplements are presented in Table 4. Use of any of the vitamins included in the interview was reported by 27% of the case patients and by 35% of the control subjects (OR = 0.7; 95% CI = 0.5-1.1). Similarly, use of multivitamins, specific vitamins, or cod-liver oil was not associated with significant reductions in risk. A variable combining dietary vitamin C and vitamin C from supplements yielded ORs similar to those seen for vitamin C from supplements only (data not shown). Risks were nonsignificantly elevated for use of supplements containing vitamin B (complex) or vitamin A.

There was some elevation in risk associated with the consumption of hot coffee which, however, did not reach statistical significance (OR = 1.5; 95% CI = 0.6-3.5). However, the risk did not increase with frequency of consumption (ORs = 1.4, 1.4, 1.3, and 1.5 for coffee consumption of <8, 8-14, 15-28, and > 28 cups of coffee per week, respectively). Risk for consumption of hot tea was only slightly elevated, also without statistical significance (OR = 1.2; 95% CI = 0.8-1.8), and there was no risk gradient with the amount consumed (data not shown).

Table 4. ORs for adenocarinomas of the esophagus and esophagogastric junction in white men according to consumption of vitamin supplements

Vitamin supplement	No. of case patients	No. of control subjects	OR*	95% CI
Never took vitamins	115	428	1.0	
Took vitamins	47	266	0.7	0.5-1.1
Don't know	12	56		
Took multivitamins	34	213	0.7	0.4-1.1
<10 y	13	82	0.7	0.4-1.4
≥10 y	21	127	0.7	0.4-1.1
Took vitamin B (complex)	16	61	1.1	0.6-2.2
<10 y	7	37	0.8	0.3-2.1
≥10 y	9	24	1.6	0.6-3.7
Took vitamin C	21	128	0.8	0.4-1.3
<10 y	7	65	0.5	0.2-1.2
≥10 y	14	62	1.1	0.5-2.1
Took vitamin A	9	23	1.8	0.7-4.2
Took cod-liver oil	4	20	0.6	0.2-1.9

*All estimates were adjusted for age, area, smoking, liquor use, and income and relative to risk of 1.0 for control subjects who never took vitamins.

Discussion

Because of its rarity in the past, adenocarcinoma of the esophagus has been infrequently studied and its etiology remains unknown. However, the abrupt and steep rise in the incidence of this malignancy during the past 20 years (*2*) has raised some concerns and has produced enough cases to allow separate analyses of adenocarcinoma and squamous cell carcinoma in this case–control investigation of esophageal cancer. While these two types of esophageal cancer have distinctly different demographic patterns (i.e., incidence rates of squamous cell tumors are more than five times higher among black men than among white men, whereas the incidence rates for adenocarcinoma are more than three times higher in white men compared with black men), the three main risk factors identified for adenocarcinoma in previous analyses of these data—smoking, alcohol consumption, and lower socioeconomic status (*5*)—are also well-established risk factors for squamous cell carcinoma. The strength of these associations is, however, much reduced for esophageal adenocarcinoma compared with squamous cell carcinoma.

In contrast, the major finding from the current analysis clearly differs between the two histologies. High-risk populations for esophageal squamous cell carcinoma are generally malnourished, and risks tend to increase as BMI decreases (*11,12*). In this study of adenocarcinoma, obesity (upper quartile of BMI) was associated with a significant risk three times that prevailing in the lowest quartile. No significant associations, however, were noted for the following factors that may be related to obesity: total calories from food, number of meals eaten per day, and total fat intake. A similar, although weaker, relationship has been reported between BMI and adenocarcinomas of the esophagus and gastric cardia combined (*12*). The mechanism by which obesity might affect the risk of esophageal adenocarcinoma is unclear, although it may be linked to the predisposition of obese individuals to gastroesophageal reflux disease and to the often-associated hiatal hernia (*13*). Reflux esophagitis is a major risk factor for Barrett's esophagus (*14*), which in turn is a precursor lesion for esophageal adenocarcinoma (*3,4*). It is relevant that other risk factors for esophageal adenocarcinoma—cigarette smoking and alcohol consumption—also contribute to reflux esophagitis (*14*). Although further study is needed to clarify the relationship between BMI and esophageal adenocarcinoma, it is noteworthy that national survey data for the time period 1976 through 1991 have documented an increase in BMI and in the proportion of white males classified as being overweight (*15*). If the relationship of esophageal adenocarcinoma to obesity is causal, it may at least partially account for the upward trend in incidence.

Our analysis of dietary patterns revealed an elevated risk for those consuming the lowest amount of vegetables but no real evidence of a dose-related protective effect with increasing consumption. The effect was stronger with some evidence of dose–response for the subcategories of cruciferous vegetables and vegetables consumed raw. There was little evidence of a relationship with fruit consumption overall, although a significantly elevated risk was seen for those consuming the least amount of raw fruit.

When risks for BMI and selected dietary variables were analyzed separately for case patients with adenocarcinomas of the esophagogastric junction and esophagus, patterns of risk were similar. However, the ORs for BMI tended to be somewhat higher and the ORs for fiber and cruciferous vegetables tended to be somewhat lower in the case patients with adenocarcinoma of the esophagus.

Fruits and vegetables contain a variety of substances suggested as having potential anticarcinogenic effects at various sites (*16,17*). These substances include carotenoids, certain vitamins (particularly A, C, and E), dietary fiber, indoles, and isothiocyanates. Cruciferous vegetables, in particular, contain high levels of indoles, isothiocyanates, and dithiolthiones, which have shown protective effects in animal models (*17,18*). These vegetables also contain high levels of vitamin C, an antioxidant that reduces the endogenous formation of nitrosamines (*16,19*). While nitrosamine formation may be inhibited by the consumption of raw fruits and vegetables (*16,17*), cooked vegetables may lack this protective effect (*20,21*).

Sorting out the possible protective ingredients in fruits and/or vegetables is difficult, particularly with the limited sample size of this investigation, but a clue emerged from the analysis of specific nutrient consumption. There was little evidence suggesting the role of either vitamin A or C consumption overall or in supplements, but a significant protective effect was associated with increasing intake of fiber. Although potential mechanisms of action are unclear, fiber deficiency has been suggested as a risk factor for hiatal hernia on the basis of geographic surveys by Burkitt (*22*). Thus, further attention should be given to the possible role of dietary fiber across the spectrum of reflux esophagitis, Barrett's esophagus, and esophageal adenocarcinoma. It is possible that dietary fiber may have a mechanical cleansing or clearance action in the upper digestive tract that removes or dilutes carcinogenic substances from epithelial surfaces. This has been suggested as a mechanism by which fiber was found to reduce the risk of oral cancer (*23,24*). Although there is no established dietary treatment for ulcer, reflux disease, and hiatal hernia, men with these conditions were likely to have made some of the following changes to treat symptoms—small, frequent meals and the avoidance of peppers, spicy foods, fatty foods, citrus juices, alcohol, and tobacco. None of these changes would explain the dietary findings reported in this study.

As with any exploratory study of an infrequently studied condition, we cannot exclude the possibility that some findings may arise by chance alone, that our limited sample size yielded inadequate statistical power to detect important associations, or that response or selection bias may have influenced results. However, when we compared characteristics (e.g., age, education, income, geographic area, smoking status, alcohol intake, history of ulcer, and BMI) of control subjects with acceptable and unacceptable diet records, the two groups were similar. In addition, the cut points for BMI in our study at 23, 25, and 27 kg/m^2 are nearly identical to those for white males aged 65-74 years in NHANES II (23, 25, and 28 kg/m^2) (*25*). There was, of

Appendix table 1. Individual foods included in each food group*

Food group	Individual foods
Dairy products	Cheese, milk, or ice cream
Bread, grains, and cereal	Bread; rolls or biscuits; cold cereal; hot cereal; rice; and spaghetti, macaroni, or noodles
Breaded and fried foods	Chicken; beef; fish; french fries, onion rings, or hush puppies; pork chops; and vegetables (e.g., okra, eggplant, or tomatoes)
Meat, poultry, and fish	Bacon or sausage; chicken; beef; fish; liver, liverwurst, or chopped liver; lunch meats; hot dogs, mixed dish with meat (e.g., chili, pork and beans, or spaghetti and meat balls); other pork or ham; and stew
Poultry and fish	Chicken and fish
Red meat	Excludes chicken and fish from the "Meat, poultry, and fish" list
Processed meats	Bacon or sausage; lunch meat; hot dogs; and other pork or ham
Fruits	Apples or pears; apricots; bananas; cantaloupe; grapefruit; oranges or tangerines; orange or grapefruit juice; fresh peaches or nectarines; canned peaches; and watermelon
Citrus fruits and juices	Grapefruit, oranges, or tangerines; orange or grapefruit juice
Citrus fruits	Grapefruit, oranges, or tangerines
Noncitrus fruits	Excludes grapefruit; oranges or tangerines; and orange or grapefruit juice from the "Fruits" list
Raw fruits	Excludes apricots; canned peaches; and orange or grapefruit juice from the "Fruits" list
Vegetables	Green string beans or lima beans; red beets; broccoli; cooked cabbage; coleslaw; carrots; cauliflower; southern greens (collard and mustard greens or kale); okra; green peas; black-eyed peas or cow peas; white potatoes; sweet potatoes or yams; raw tomatoes; cooked tomatoes; tomato or V8 juice; tossed salad; spinach; vegetable soup; mixed vegetables; and zucchini or yellow squash
Cruciferous/vitamin C vegetables	Broccoli, cooked cabbage, coleslaw, cauliflower, or southern greens
Dark green vegetables	Broccoli, southern greens, or spinach
Dark yellow vegetables	Carrots; mixed vegetables with carrots; and sweet potatoes or yams
Legumes	Green peas, black-eyed peas or cow peas, or green string beans or lima beans
Raw vegetables	From question on questionnaire, "How often did you usually have any raw vegetables?"

*The following additional foods were included in the nutrient analysis: doughnuts; cake, pie, or cookies; salty snacks; tomato or V8 juice; vitamin C-fortified drinks; and eggs.

course, no way to assess potential differences between respondents and nonrespondents for the major risk factors.

Our findings of an increased risk with obesity and decreased risks with consumption of raw fruits and vegetables and dietary fiber have underlying biologic plausibility and provide leads for further etiologic investigations of esophageal adenocarcinoma. The association seen with obesity is especially provocative, since it may help to explain some of the remarkable increases reported in the incidence of this tumor.

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Notes

Supported by Public Health Service contracts N01CP51090, N01CP51089, N01CP51092, N01CN05225, N01CN31022, and N01CN05227 from the National Cancer Institute, National Institutes of Health, Department of Health and Human Services.

We thank Ruth Thomson of Westat, Inc., for her assistance in study management and coordination; Roy Van Dusen of Information Management Systems, Inc., for computer support; study coordinators, interviewers, and support staff in each center for their diligent work; and the many physicians, hospital, and study participants who cooperated in this project.

Manuscript received June 24, 1994; revised August 31, 1994; accepted October 6, 1994.